APHORISMS

CONCERNING

IDEAS, SCIENCE, AND THE LANGUAGE OF SCIENCE.

BY THE

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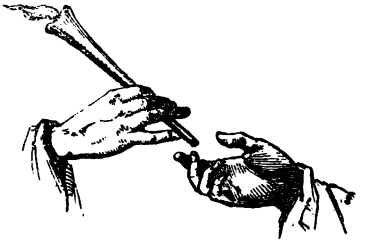

Λαμπάδια ἔχοντες διαδώσουσιν ἀλλήλοις.

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THE views presented in the following Aphorisms are further developed in the *Philosophy of the Inductive Sciences.*

APHORISMS CONCERNING IDEAS.

I.

Man is the Interpreter of Nature, Science the right interpretation.

II.

The *Senses* place before us the *Characters* of the Book of Nature; but these convey no knowledge to us, till we have discovered the Alphabet by which they are to be read.

III.

The *Alphabet*, by means of which we interpret Phenomena, consists of the *Ideas* existing in our own minds; for these give to the phenomena that coherence and significance which is not an object of sense.

IV.

The antithesis of *Sense* and *Ideas* is the foundation of the Philosophy of Science. No knowledge can exist without the union, no philosophy without the separation, of these two elements.

V.

Fact and *Theory* correspond to Sense on the one hand, and to Ideas on the other, so far as we are *conscious* of our Ideas: but all facts involve ideas *unconsciously;* and thus the distinction of Facts and Theories is not tenable, as that of Sense and Ideas is.

VI.

Sensations and Ideas in our knowledge are like Matter and Form in bodies. Matter cannot exist without Form, nor Form

without Matter: yet the two are altogether distinct and opposite. There is no possibility either of separating, or of confounding them. The same is the case with Sensations and Ideas.

VII.

Ideas are not *trans*formed, but *in*formed Sensations; for without ideas, sensations have no form.

VIII.

The Sensations are the *Objective*, the Ideas the *Subjective* part of every act of perception or knowledge.

IX.

General terms denote *Ideal Conceptions*, as a *circle*, an *orbit*, a *rose*. These are not *images* of real things, as was held by the Realists, but conceptions: yet they are conceptions, not bound together by mere *name*, as the Nominalists held, but by an idea.

X.

It has been said by some, that all Conceptions are merely *states* or *feelings of the mind*, but this assertion only tends to confound what it is our business to distinguish.

XI.

Observed Facts are connected so as to produce new truths, by superinducing upon them an Idea: and such truths are obtained *by Induction*.

XII.

Truths once obtained by legitimate Induction are Facts: these Facts may be again connected, so as to produce higher truths: and thus we advance to *Successive Generalizations*.

XIII.

Truths obtained by Induction are made compact and permanent by being expressed in *Technical Terms*.

XIV.

Experience cannot conduct us to universal and necessary truths:—Not to universal, because she has not tried all cases:—Not to necessary, because necessity is not a matter to which experience can testify.

XV.

Necessary truths derive their necessity from the *Ideas* which they involve; and the existence of necessary truths proves the existence of Ideas not generated by experience.

XVI.

In Deductive Reasoning, we cannot have any truth in the conclusion which is not virtually contained in the premises.

XVII.

In order to acquire any exact and solid knowledge, the student must possess with perfect precision the ideas appropriate to that part of knowledge: and this precision is tested by the student's *perceiving* the axiomatic evidence of the *axioms* belonging to each *Fundamental Idea*.

XVIII.

The Fundamental Ideas which it is most important to consider, as being the Bases of the Material Sciences, are the Ideas of *Space*, *Time* (including Number), *Cause* (including Force and Matter), *Outness* of Objects, and *Media* of Perception of Secondary Qualities, *Polarity* (Contrariety), Chemical *Composition* and *Affinity*, *Substance*, *Likeness* and Natural *Affinity*, *Means and Ends* (whence the notion of Organization), *Symmetry*, and the Ideas of *Vital Powers*.

XIX.

The Sciences which depend upon the Ideas of Space and Number are *Pure* Sciences, not *Inductive* Sciences: they do not infer special Theories from Facts, but deduce the conditions of all theory from Ideas. The Elementary Pure Sciences, or Elementary Mathematics, are Geometry, Theoretical Arithmetic and Algebra.

XX.

The Ideas on which the Pure Sciences depend, are those of *Space* and *Number*; but Number is a modification of the conception of Repetition, which belongs to the Idea of *Time*.

XXI.

The *Idea of Space* is not derived from experience, for experience of external objects *pre*supposes bodies to exist in Space. Space is a condition under which the mind receives the impressions of sense, and therefore the relations of space are necessarily and universally true of all perceived objects. Space is a *form* of our perceptions, and regulates them, whatever the *matter* of them may be.

XXII.

Space is not a general notion collected by abstraction from particular cases; for we do not speak of *Spaces* in general, but of universal or absolute *Space*. Absolute space is infinite. All special spaces are *in* absolute space, and are parts of it.

XXIII.

Space is not a real object or thing, distinct from the objects which exist in it; but it is a real condition of the existence of external objects.

XXIV.

We have an *Intuition* of objects in space; that is, we contemplate objects as *made up* of spatial parts, and apprehend their spatial relations by the same act by which we apprehend the objects themselves.

XXV.

Form or figure is space limited by boundaries. Space has necessarily *three* dimensions, length, breadth, depth; and no others which cannot be resolved into these.

XXVI.

The Idea of Space is exhibited for scientific purposes, by the *Definitions* and *Axioms* of Geometry; such, for instance, as these:—the *Definition of a Right Angle*, and *of a Circle*;—the *Definition of Parallel Lines*, and the *Axiom* concerning them;—the Axiom that *two straight lines cannot inclose a space.* These Definitions are necessary, not arbitrary; and the Axioms are needed as well as the Definitions, in order to express the necessary conditions which the Idea of Space imposes.

XXVII.

The Definitions and Axioms of Elementary Geometry do not *completely* exhibit the Idea of Space. In proceeding to the Higher Geometry, we may introduce other additional and independent Axioms; such as that of Archimedes, that *a curve line which joins two points is less than any broken line joining the same points and including the curve line.*

XXVIII.

The perception of a *solid object* by sight requires that *act* of mind by which, from figure and shade, we infer distance and position in space. The perception of *figure* by sight requires that act of mind by which we give an outline to each object.

XXIX.

The perception of form by touch is not an impression on the passive sense, but requires an *act* of our muscular frame by which we become aware of the position of our own limbs. The perceptive faculty involved in this act has been called *the muscular sense.*

XXX.

The *Idea of Time* is not derived from experience, for experience of changes *pre*supposes occurrences to take place in Time. Time is a condition under which the mind receives the impressions of sense, and therefore the relations of time are necessarily

and universally true of all perceived occurrences. Time is a *form* of our perceptions, and regulates them, whatever the *matter* of them may be.

XXXI.

Time is not a general notion collected by abstraction from particular cases. For we do not speak of particular *Times* as examples of time in general, but as parts of a single and infinite *Time*.

XXXII.

Time, like Space, is a form, not only of perception, but of *Intuition*. We consider the whole of any time as *equal* to the *sum* of the parts; and an occurrence as *coinciding* with the portion of time which it occupies.

XXXIII.

Time is analogous to Space of *one dimension:* portions of both have a beginning and an end, are long or short. There is nothing in Time which is analogous to Space of two, or of three, dimensions, and thus nothing which corresponds to Figure.

XXXIV.

The Repetition of a set of occurrences, as, for example, strong and weak, or long and short sounds, according to a steadfast order, produces *Rhythm*, which is a conception peculiar to Time, as Figure is to Space.

XXXV.

The simplest form of Repetition is that in which there is no variety, and this gives rise to the conception of *Number*.

XXXVI.

The simplest numerical truths are seen by Intuition; when we endeavour to deduce the more complex from these simplest, we employ such maxims as these:—*If equals be added to equals the wholes are equal:—If equals be subtracted from equals the remainders are equal:—The whole is equal to the sum of all its parts.*

XXXVII.

The Perception of Time involves a constant and latent kind of memory, which may be termed a *Sense of Succession*. The Perception of Number also involves this Sense of Succession, although in small numbers we appear to apprehend the units simultaneously and not successively.

XXXVIII.

The Perception of Rhythm is not an impression on the passive sense, but requires an *act* of thought by which we connect and group the strokes which form the Rhythm.

XXXIX.

Intuitive is opposed to *discursive* reason. In intuition, we obtain our conclusions by dwelling upon *one* aspect of the fundamental Idea; in discursive reasoning, we combine *several* aspects of the Idea, (that is, several axioms,) and reason from the combination.

XL.

Geometrical deduction (and deduction in general) is called *synthesis*, because we introduce, at successive steps, the results of new principles. But in reasoning on the relations of space, we sometimes go on *separating* truths into their component truths, and these into other component truths; and so on; and this is geometrical *analysis*.

XLI.

Among the foundations of the Higher Mathematics, is the *Idea of Symbols* considered as general *Signs* of Quantity. This idea of a Sign is distinct from, and independent of other ideas. The axiom to which we refer in reasoning by means of Symbols of quantity is this:—*The interpretation of such symbols must be perfectly general.* This Idea and Axiom are the bases of Algebra in its most general form.

XLII.

Among the foundations of the Higher Mathematics is also the *Idea of a Limit*. The Idea of a Limit cannot be superseded by any other definitions or Hypotheses. The Axiom which we employ in introducing this Idea into our reasoning is this:—*What is true up to the Limit is true at the Limit.* This Idea and Axiom are the bases of all Methods of Limits, Fluxions, Differentials, Variations, and the like.

XLIII.

There is a *pure* Science of Motion, which does not depend upon observed facts, but upon the Idea of motion. It may also be termed *Pure Mechanism*, in opposition to Mechanics Proper, or *Machinery*, which involves the mechanical conceptions of force and matter. It has been proposed to name this Pure Science of Motion, *Kinematics*.

XLIV.

The pure mathematical sciences must be successfully cultivated, in order that the progress of the principal inductive sciences may take place. This appears in the case of Astronomy, in which Science, both in ancient and in modern times, each advance of the theory has depended upon the previous solution of problems in pure mathematics. It appears also inversely in the Science of the Tides, in which, at present, we cannot advance in the theory, because we cannot solve the requisite problems in the Integral Calculus.

XLV.

The *Idea of Cause*, modified into the conceptions of mechanical cause, or Force, and resistance to force, or Matter, is the foundation of the Mechanical Sciences; that is, Mechanics, (including Statics and Dynamics,) Hydrostatics, and Physical Astronomy.

XLVI.

The Idea of Cause is not derived from experience; for in judging of occurrences which we contemplate, we consider them

as being, universally and necessarily, Causes and Effects, which a finite experience could not authorize us to do. The Axiom, that every event must have a cause, is true independently of experience, and beyond the limits of experience.

XLVII.

The Idea of Cause is expressed for purposes of science by these three Axioms:—*Every Event must have a Cause:—Causes are measured by their Effects:—Reaction is equal and opposite to Action.*

XLVIII.

The Conception of Force involves the Idea of Cause, as applied to the motion and rest of bodies. The conception of *force* is suggested by muscular action exerted: the conception of *matter* arises from muscular action resisted. We necessarily ascribe to all bodies solidity and inertia, since we conceive Matter as that which cannot be compressed or moved without resistance.

XLIX.

Mechanical Science depends on the Conception of Force; and is divided into *Statics*, the doctrine of Force preventing motion, and *Dynamics*, the doctrine of Force producing motion.

L.

The Science of Statics depends upon the Axiom, that Action and Reaction are equal, which in Statics assumes this form: —*When two equal weights are supported on the middle point between them, the pressure on the fulcrum is equal to the sum of the weights.*

LI.

The Science of Hydrostatics depends upon the Fundamental Principle that *fluids press equally in all directions.* This Principle necessarily results from the conception of a Fluid, as a body of which the parts are perfectly moveable in all directions. For since the Fluid is a body, it can transmit pressure; and the transmitted pressure is equal to the original pressure, in virtue of the

Axiom that Reaction is equal to Action. That the Fundamental Principle is not derived from experience, is plain both from its evidence and from its history.

LII.

The Science of Dynamics depends upon the three Axioms above stated respecting Cause. The First Axiom,—that every change must have a Cause,—gives rise to the First Law of Motion,—that *a body not acted upon by a force will move with a uniform velocity in a straight line.* The Second Axiom,—that Causes are measured by their Effects,—gives rise to the Second Law of Motion,—that *when a force acts upon a body in motion, the effect of the force is compounded with the previously existing motion.* The Third Axiom,—that *Reaction is equal and opposite to Action*,—gives rise to the Third Law of Motion, which is expressed in the same terms as the Axiom; Action and Reaction being understood to signify momentum gained and lost.

LIII.

The above Laws of Motion, historically speaking, were established by means of experiment: but since they have been discovered and reduced to their simplest form, they have been considered by many philosophers as self-evident. This result is principally due to the introduction and establishment of terms and definitions, which enable us to express the Laws in a very simple manner.

LIV.

In the establishment of the Laws of Motion, it happened, in several instances, that Principles were assumed as self-evident which do not now appear evident, but which have since been demonstrated from the simplest and most evident principles. Thus it was assumed that *a perpetual motion is impossible*;—that *the velocities of bodies acquired by falling down planes or curves of the same vertical height are equal*;—that *the actual descent of the centre of gravity is equal to its potential ascent.* But we are not hence to suppose that these assumptions were made without ground: for since they really follow from the laws of motion,

they were probably, in the minds of the discoverers, the results of undeveloped demonstrations which their sagacity led them to divine.

LV.

It is a *Paradox* that Experience should lead us to truths confessedly universal, and apparently necessary, such as the Laws of Motion are. The *Solution* of this paradox is, that these laws are interpretations of the Axioms of Causation. The Axioms are universally and necessarily true, but the right interpretation of the terms which they involve, is learnt by experience. Our Idea of Cause supplies the *Form*, Experience, the *Matter*, of these Laws.

LVI.

Primary Qualities of Bodies are those which we can conceive as directly perceived; *Secondary* Qualities are those which we conceive as perceived by means of a Medium.

LVII.

We necessarily perceive bodies as *without* us: the Idea of *Externality* is one of the conditions of perception.

LVIII.

We necessarily assume a *Medium* for the perceptions of Light, Colour, Sound, Heat, Odours, Tastes; and this Medium *must* convey impressions by means of its mechanical attributes.

LIX.

Secondary Qualities are not *extended* but *intensive*; their effects are not augmented by addition of parts, but by increased operation of the medium. Hence they are not measured directly, but by *scales;* not by *units*, but by *degrees*.

LX.

In the Scales of Secondary Qualities, it is a condition (in order that the scale may be complete,) that every example of the quality must either *agree* with one of the degrees of the Scale, or lie between two *contiguous* degrees.

LXI.

We perceive *by means of* a medium and *by means of* impressions on the nerves: but we do not (by our senses,) perceive either the medium or the impressions on the nerves.

LXII.

The *Prerogatives of the Sight* are, that by this sense we necessarily and immediately apprehend the *position* of its objects: and that from visible circumstances, we *infer* the *distance* of objects from us, so readily that we seem to perceive and not to infer.

LXIII.

The *Prerogatives of the Hearing* are, that by this sense we perceive relations perfectly precise and definite between two notes, namely, *Musical Intervals* (as an *Octave*, a *Fifth*); and that when two notes are perceived together, they are apprehended as distinct, (a *Chord*,) and as having a certain relation, (*Concord* or *Discord*.)

LXIV.

The Sight cannot decompose a compound colour into simple colours, or distinguish a compound from a simple colour. The Hearing cannot directly perceive the place, still less the distance, of its objects. We infer these obscurely and vaguely from audible circumstances.

LXV.

The *First Paradox of Vision* is, that we see objects *upright*, though the images on the retina are *inverted*. The solution is, that we do not see the image on the retina at all, we only see by means of it.

LXVI.

The *Second Paradox of Vision* is, that we see objects *single*, though there are two images on the retinas, one in each eye. The explanation is, that it is a Law of Vision that we see (small or distant) objects single, when their images fall on *corresponding points* of the two retinas.

LXVII.

The law of single vision for *near* objects is this:—When the two images in the two eyes are situated, part for part, nearly but not exactly, upon corresponding points, the object is apprehended as single and solid if the two images are such as would be produced by a single solid object seen by the eyes separately.

LXVIII.

The ultimate object of each of the Secondary Mechanical Sciences is, to determine the nature and laws of the processes by which the impression of the Secondary Quality treated of is conveyed: but before we discover the *cause*, it may be necessary to determine the *laws* of the phenomena; and for this purpose a *Measure* or *Scale* of each quality is necessary.

LXIX.

Secondary qualities are measured by means of such effects as can be estimated in number or space.

LXX.

The Measure of Sounds, as high or low, is the *Musical Scale*, or *Harmonic Canon*.

LXXI.

The Measures of Pure Colours are the *Prismatic Scale;* the same, including *Fraunhofer's Lines;* and *Newton's Scale* of Colours. The principal Scales of Impure Colours are *Werner's Nomenclature* of Colours, and *Merimée's Nomenclature* of Colours.

LXXII.

The Idea of *Polarity* involves the conception of contrary properties in contrary directions:—the properties being, for example, attraction and repulsion, darkness and light, synthesis and analysis; and the contrary directions being those which are directly opposite, or, in some cases, those which are at right angles.

LXXIII. (*Doubtful.*)

Coexistent polarities are fundamentally identical.

LXXIV.

The Idea of Chemical *Affinity*, as implied in Elementary Composition, involves peculiar conceptions. It is not properly expressed by assuming the qualities of bodies to *resemble* those of the elements, or to depend on the *figure* of the elements, or on their *attractions*.

LXXV.

Attractions take place between bodies, affinities between the particles of a body. The former may be compared to the alliances of states, the latter to the ties of family.

LXXVI.

The governing principles of chemical affinity are, that it is *elective;* that it is *definite;* that it *determines the properties* of the compound; and that *analysis is possible.*

LXXVII.

We have an Idea of *Substance:* and an axiom involved in this Idea is, that *the weight of a body is the sum of the weights of all its elements.*

LXXVIII.

Hence Imponderable Fluids are not to be admitted as chemical elements.

LXXIX.

The Doctrine of Atoms is admissible as a mode of expressing and calculating laws of nature; but is not proved by any fact, chemical or physical, as a philosophical truth.

LXXX.

We have an Idea of *Symmetry;* and an axiom involved in this Idea is, that in a symmetrical natural body, if there be a tendency to modify any member in any manner, there is a tendency to modify all the corresponding members in the same manner.

LXXXI.

All hypotheses respecting the manner in which the elements of inorganic bodies are arranged in space, must be constructed with regard to the general facts of crystallization.

LXXXII.

When we consider any object as *one*, we give unity to it by an act of thought. The condition which determines what this unity shall include, and what it shall exclude, is this;—that assertions concerning the one thing shall be possible.

LXXXIII.

We collect individuals into *kinds* by applying to them the Idea of Likeness. Kinds of things are not determined by definitions, but by this condition;—that general assertions concerning such kinds of things shall be possible.

LXXXIV.

The *names* of kinds of things are governed by their use; and that may be a right name in one use which is not so in another. A whale is not a *fish* in natural history, but it is a *fish* in commerce and law.

LXXXV.

We take for granted that each kind of things has a special *character* which may be expressed by a Definition. The ground of our assumption is this;—that reasoning must be possible.

LXXXVI.

The "Five Words," *genus*, *species*, *difference*, *property*, *accident*, were used by the Aristotelians, in order to express the subordination of kinds, and to describe the nature of definitions and propositions. In modern times, these technical expressions have been more referred to by Natural Historians than by Metaphysicians.

LXXXVII.

The construction of a Classificatory Science includes *Terminology*, the formation of a descriptive language;—*Diataxis*, the Plan of the System of Classification, called also the *Systematick*;—*Diagnosis*, the Scheme of the Characters by which the different Classes are known, called also the *Characteristick*. *Physiography* is the knowledge which the System is employed to convey. Diataxis includes *Nomenclature*.

LXXXVIII.

Terminology must be conventional, precise, constant; copious in words, and minute in distinctions, according to the needs of the science. The student must understand the terms, *directly* according to the convention, not through the medium of explanation or comparison.

LXXXIX.

The *Diataxis*, or Plan of the System, may aim at a Natural or an Artificial System. But no classes can be absolutely artificial, for if they were, no assertions could be made concerning them.

XC.

An *Artificial System* is one in which the *smaller* groups (the Genera) are *natural*; and in which the *wider* divisions (Classes, Orders) are constructed by the *peremptory* application of selected Characters; (selected, however, so as not to break up the smaller groups.)

XCI.

A *Natural System* is one which attempts to make *all* the divisions *natural*, the widest as well as the narrowest; and therefore applies *no* characters *peremptorily*.

XCII.

Natural Groups are best described, not by any definition which marks their boundaries, but by a *Type* which marks their centre. The Type of any natural group is an example which possesses in a marked degree all the leading characters of the class.

XCIII.

A Natural Group is steadily fixed, though not precisely limited; it is given in position, though not circumscribed; it is determined, not by a boundary without, but by a central point within;—not by what it strictly excludes, but by what it eminently includes;—by a Type, not by a Definition.

XCIV.

The prevalence of Mathematics as an element of education has made us think Definition the philosophical mode of fixing the meaning of a word: if (Scientific) Natural History were introduced into education, men might become familiar with the fixation of the signification of words by Types; and this agrees more nearly with the common processes by which words acquire their significations.

XCV.

The attempts at Natural Classification are of three sorts; according as they are made by the process of *blind trial*, of *general comparison*, or of *subordination of characters*. The process of Blind Trial professes to make its classes by attention to *all* the characters, but without proceeding methodically. The process of General Comparison professes to enumerate all the characters, and forms its classes by the *majority*. Neither of these methods can really be carried into effect. The method of Subordination of Characters considers some characters as *more important* than others; and this method gives more consistent results than the others. This method, however, does not depend upon the Idea of Likeness only, but introduces the Idea of Organization or Function.

XCVI.

A *Species* is a collection of individuals which are descended from a common stock, or which resemble such a collection as much as these resemble each other: the resemblance being opposed to a *definite* difference.

XCVII.

A *Genus* is a collection of species which resemble each other more than they resemble other species: the resemblance being opposed to a *definite* difference.

XCVIII.

The *Nomenclature* of a Classificatory Science is the collection of the names of the Species, Genera, and other divisions. The *binary* nomenclature, which denotes a species by the *generic* and *specific* name, is now commonly adopted in Natural History.

XCIX.

The *Diagnosis*, or Scheme of the Characters, comes, in the order of philosophy, after the Classification. The characters do not *make* the classes, they only enable us to *recognize* them. The Diagnosis is an Artificial Key to a Natural System.

C.

The basis of all Natural Systems of Classification is the Idea of Natural Affinity. The Principle which this Idea involves is this:—Natural arrangements, obtained from *different* sets of characters, must *coincide* with each other.

CI.

In order to obtain a Science of Biology, we must analyse the Idea of Life. It has been proved by the biological speculations of past time, that organic Life cannot rightly be resolved into mechanical or chemical forces, or the operation of a vital fluid, or of a soul.

CII.

Life is a System of Vital Forces; and the conception of such Forces involves a peculiar Fundamental Idea.

CIII.

Mechanical, chemical, and vital Forces form an ascending progression, each including the preceding. Chemical Affinity

includes in its nature Mechanical Force, and may often be practically resolved into Mechanical Force. (Thus the ingredients of gunpowder, liberated from their chemical union, exert great mechanical Force: a galvanic battery acting by chemical process does the like.) Vital Forces include in their nature both chemical Affinities and mechanical Forces: for Vital Powers produce both chemical changes, (as digestion,) and motions which imply considerable mechanical force, (as the motion of the sap and of the blood.)

CIV.

In *voluntary* motions, Sensations produce Actions, and the connexion is made by means of Ideas: in *reflected* motions, the connexion neither seems to be nor is made by means of Ideas: in *instinctive* motions, the connexion is such as requires Ideas, but we cannot believe the Ideas to exist.

CV.

The assumption of a Final Cause in the structure of each part of animals and plants is as inevitable as the assumption of an Efficient Cause for every event. The maxim that in organized bodies nothing is *in vain*, is as necessarily true as the maxim that nothing happens *by chance*.

CVI.

The idea of living beings as subject to *disease* includes a recognition of a Final Cause in organization; for disease is a state in which the vital forces do not attain their *proper ends*.

CVII.

The Palætiological Sciences depend upon the Idea of Cause; but the leading conception which they involve is that of *historical cause*, not mechanical cause.

CVIII.

Each Palætiological Science, when complete, must possess three members: the *Phenomenology*, the *Ætiology*, and the *Theory*.

CIX.

There are, in the Palætiological Sciences, two antagonist doctrines: *Catastrophes* and *Uniformity*. The doctrine of a *uniform course of nature* is tenable only when we extend the notion of uniformity so far that it shall include catastrophes.

CX.

The Catastrophist constructs Theories, the Uniformitarian demolishes them. The former adduces evidence of an Origin, the latter explains the evidence away. The Catastrophist's dogmatism is undermined by the Uniformitarian's skeptical hypotheses. But when these hypotheses are asserted dogmatically, they cease to be consistent with the doctrine of uniformity.

CXI.

In each of the Palætiological Sciences, we can ascend to remote periods by a chain of causes, but in none can we ascend to a *beginning* of the chain.

CXII.

In contemplating the series of causes and effects which constitutes the world, we necessarily assume a *First Cause* of the whole series.

CXIII.

The Palætiological Sciences point backwards with lines which are broken, but which all converge to the *same* invisible point: and this point is the Origin of the Moral and Spiritual, as well as of the natural world.

APHORISMS CONCERNING SCIENCE.

I.

The two processes by which Science is constructed are the *Explication of Conceptions* and the *Colligation of Facts.*

II.

The Explication of Conceptions, as requisite for the progress of science, has been effected by means of discussions and controversies among scientists; often by debates concerning definitions; these controversies have frequently led to the establishment of a Definition; but along with the Definition, a corresponding Proposition has always been expressed or implied. The essential requisite for the advance of science is the clearness of the Conception, not the establishment of a Definition. The construction of an exact Definition is often very difficult. The requisite conditions of clear Conceptions may often be expressed by Axioms as well as by Definitions.

III.

Conceptions, for purposes of science, must be *appropriate* as well as clear: that is, they must be modifications of that Fundamental Idea, by which the phenomena can really be interpreted. This maxim may warn us from error, though it may not lead to discovery. Discovery depends upon the previous cultivation or natural clearness of the appropriate Idea, and therefore *no discovery is the work of accident.*

IV.

Facts are the materials of science, but all Facts involve Ideas. Since, in observing Facts, we cannot exclude Ideas, we must, for the purposes of science, take care that the Ideas are clear and rigorously applied.

V.

The last Aphorism leads to such Rules as the following:—That Facts, for the purposes of material science, must involve Conceptions of the Intellect only, and not Emotions:—That Facts must be observed with reference to our most exact conceptions, Number, Place, Figure, Motion:—That they must also be observed with reference to any other exact conceptions which the phenomena suggest, as Force, in mechanical phenomena, Concord, in musical.

VI.

The resolution of complex Facts into precise and measured partial Facts, we call the *Decomposition of Facts*. This process is requisite for the progress of science, but does not necessarily lead to progress.

VII.

Science begins with *common* observation of facts; but even at this stage, requires that the observations be precise. Hence the sciences which depend upon space and number were the earliest formed. After common Observation, come scientific *Observation* and *Experiment*.

VIII.

The Conceptions by which Facts are bound together, are suggested by the sagacity of discoverers. This sagacity cannot be taught. It commonly succeeds by guessing; and this success seems to consist in framing several *tentative hypotheses* and selecting the right one. But a supply of appropriate hypotheses cannot be constructed by rule, nor without inventive talent.

IX.

The truth of tentative hypotheses must be tested by their application to facts. The discoverer must be ready, carefully to try his hypotheses in this manner, and to reject them if they will not bear the test, in spite of indolence and vanity.

X.

The process of scientific discovery is cautious and rigorous, not by abstaining from hypotheses, but by rigorously comparing hypotheses with facts, and by resolutely rejecting all which the comparison does not confirm.

XI.

Hypotheses may be useful, though involving much that is superfluous, and even erroneous: for they may supply the true bond of connexion of the facts; and the superfluity and error may afterwards be pared away.

XII.

It is a test of true theories not only to account for, but to predict phenomena.

XIII.

Induction is a term applied to describe the *process* of a true Colligation of Facts by means of an exact and appropriate Conception. *An Induction* is also employed to denote the *proposition* which results from this process.

XIV.

The Consilience of Inductions takes place when an Induction, obtained from one class of facts, coincides with an Induction, obtained from another different class. This Consilience is a test of the truth of the Theory in which it occurs.

XV.

An Induction is not the mere *sum* of the Facts which are colligated. The Facts are not only brought together, but seen in a new point of view. A new mental Element is *superinduced*; and a peculiar constitution and discipline of mind are requisite in order to make this Induction.

XVI.

Although in Every Induction a new conception is superinduced upon the Facts; yet this once effectually done, the novelty

of the conception is overlooked, and the conception is considered as a part of the fact.

XVII.

The *Logic of Induction* consists in stating the Facts and the Inference in such a manner, that the evidence of the Inference is manifest; just as the Logic of Deduction consists in stating the Premises and the Conclusion in such a manner that the Evidence of the Conclusion is manifest.

XVIII.

The Logic of Deduction is exhibited by means of a certain Formula; namely, a Syllogism; and every train of deductive reasoning, to be demonstrative, must be capable of resolution into a series of such Formulæ legitimately constructed. In like manner, the Logic of Induction may be exhibited by means of certain *Formulæ;* and every train of inductive inference, to be sound, must be capable of resolution into a scheme of such Formulæ, legitimately constructed.

XIX.

The *inductive act of thought* by which several Facts are colligated into one Proposition, may be expressed by saying: *The several Facts are exactly expressed as one Fact, if, and only if, we adopt the Conceptions and the Assertion* of the Proposition.

XX.

The One Fact, thus inductively obtained from several Facts, may be combined with other Facts, and colligated with them by a new act of Induction. This process may be indefinitely repeated: and these successive processes are the *Steps* of Induction, or of *Generalization*, from the lowest to the highest.

XXI.

The relation of the successive Steps of Induction may be exhibited by means of an *Inductive Table*, in which the several Facts are indicated, and tied together by a Bracket, and the Inductive Inference placed on the other side of the Bracket; and

this arrangement repeated, so as to form a genealogical Table of each Induction, from the lowest to the highest.

XXII.

The Logic of Induction is the *Criterion of Truth* inferred from Facts, as the Logic of Deduction is the Criterion of Truth deduced from necessary Principles. The Inductive Table enables us to apply such a Criterion; for we can determine whether each Induction is verified and justified by the Facts which its Bracket includes; and if each Induction in particular be sound, the highest, which merely combines them all, must necessarily be sound also.

XXIII.

The distinction of *Fact* and *Theory* is only relative. Events and phenomena, considered as particulars which may be colligated by Induction, are *Facts;* considered as generalities already obtained by colligation of other Facts, they are *Theories.* The same event or phenomenon is a Fact or a Theory, according as it is considered as standing on one side or the other of the Inductive Bracket.

XXIV.

Inductive truths are of two kinds, *Laws of Phenomena*, and *Theories of Causes.* It is necessary to begin in every science with the Laws of Phenomena; but it is impossible that we should be satisfied to stop short of a Theory of Causes. In Physical Astronomy, Physical Optics, Geology, and other sciences, we have instances showing that we can make a great advance in inquiries after true Theories of Causes.

XXV.

Art and Science differ. The object of Science is Knowledge; the objects of Art, are Works. In Art, truth is a means to an end; in Science, it is the only end. Hence the Practical Arts are not to be classed among the Sciences.

XXVI.

Practical Knowledge, such as Art implies, is not Knowledge such as Science includes. Brute animals have a practical know-

ledge of relations of space and force; but they have no knowledge of Geometry or Mechanics.

XXVII.

The Methods by which the construction of Science is promoted are, *Methods of Observation*, *Methods of obtaining clear Ideas*, and *Methods of Induction*.

XXVIII.

The Methods of Observation of Quantity in general, are *Numeration*, which is precise by the nature of Number; the *Measurement of Space* and *of Time*, which are easily made precise; the *Conversion of Space and Time*, by which each aids the measurement of the other; the *Method of Repetition;* the *Method of Coincidences* or *Interferences*. The measurement of Weight is made precise by the *Method of Double-weighing*. Secondary Qualities are measured by means of *Scales of Degrees;* but in order to apply these Scales, the student requires the *Education of the Senses*. The Education of the Senses is forwarded by the practical study of *Descriptive Natural History*, *Chemical Manipulation*, and *Astronomical Observation*.

XXIX.

The Methods by which the acquisition of clear Scientific Ideas is promoted, are mainly two; *Intellectual Education* and *Discussion of Ideas*.

XXX.

The Idea of Space becomes more clear by studying *Geometry;* the Idea of Force, by studying *Mechanics;* the Ideas of Likeness, of Kind, of subordination of Classes, by studying *Natural History*.

XXXI.

Elementary Mechanics should now form a part of intellectual education, in order that the student may understand the Theory of Universal Gravitation: for an intellectual education should cultivate such ideas as enable the student to understand the most complete and admirable portions of the knowledge which the human race has attained to.

XXXII.

Natural History ought to form a part of intellectual education, in order to correct certain prejudices which arise from cultivating the intellect by means of mathematics alone; and in order to lead the student to see that the division of things into kinds, and the attribution and use of names, are processes susceptible of great precision.

XXXIII.

The conceptions involved in scientific truths have attained the requisite degree of clearness by means of the *Discussions* respecting ideas which have taken place among discoverers and their followers. Such discussions are very far from being unprofitable to science. They are metaphysical, and must be so: the difference between discoverers and barren reasoners is, that the former employ good, and the latter bad metaphysics.

XXXIV.

The Process of Induction may be resolved into three steps; the *Selection of the Idea*, the *Construction of the Conception*, and the *Determination of the Magnitudes*.

XXXV.

These three steps correspond to the determination of the *Independent variable*, the *Formula*, and the *Coefficients*, in mathematical investigations; or to the *Argument*, the *Law*, and the *Numerical Data*, in a Table of an Inequality.

XXXVI.

The Selection of the Idea depends mainly upon inventive sagacity: which operates by suggesting and trying various hypotheses. Some inquirers try erroneous hypotheses; and thus, exhausting the forms of error, form the Prelude to Discovery.

XXXVII.

The following Rules may be given, in order to the selection of the Idea for purposes of Induction:—the Idea and the Facts must be *homogeneous*; and the Rule must be *tested by the Facts*.

XXXVIII.

The Construction of the Conception very often includes, in a great measure, the Determination of the Magnitudes.

XXXIX.

When a series of *progressive* numbers is given as the result of observation, it may generally be reduced to law by combinations of arithmetical and geometrical progressions.

XL.

A true formula for a progressive series of numbers cannot commonly be obtained from a *narrow range* of observations.

XLI.

Recurrent series of numbers must, in most cases, be expressed by circular formulæ.

XLII.

The true construction of the conception is frequently suggested by some hypothesis; and in these cases, the hypothesis may be useful, though containing superfluous parts.

XLIII.

There are special Methods of Induction applicable to Quantity; of which the principal are, the *Method of Curves*, the *Method of Means*, the *Method of Least Squares*, and the *Method of Residues*.

XLIV.

The Method of Curves consists in drawing a curve, of which the observed quantities are the ordinates, the quantity on which the change of these quantities depends being the abscissa. Its efficacy depends upon the faculty which the eye possesses, of readily detecting regularity and irregularity in forms. It may be used to detect the laws which the observed quantities follow; and also, when the observations are inexact, it may be used to correct these observations, so as to obtain data more true than the observed facts themselves.

XLV.

The Method of Means gets rid of irregularities by taking the arithmetical mean of a great number of observed quantities. Its efficacy depends upon this; that in cases in which observed quantities are affected by other inequalities, besides that of which we wish to determine the law, the excesses *above* and defects *below* the quantities which the law in question would produce, will, in a collection of many observations, *balance* each other.

XLVI.

The Method of Least Squares is a Method of Means, in which the mean is taken according to the condition, that the sum of the squares of the errors of observation shall be the least possible which the law of the facts allows. It appears, by the doctrine of chances, that this is the *most probable* mean.

XLVII.

The Method of Residues consists in subtracting, from the quantities given by observation, the quantity given by any law already discovered; and then examining the remainder, or *Residue*, in order to discover the leading law which it follows. When this second law has been discovered, the quantity given by it may be subtracted from the first Residue; thus giving a *Second Residue*, which may be examined in the same manner; and so on. The efficacy of this method depends principally upon the circumstance of the laws of variation being successively smaller and smaller in amount (or at least in their mean effect); so that the ulterior undiscovered laws do not prevent the law in question from being *prominent* in the observations.

XLVIII.

The Method of Means and the Method of Least Squares can not be applied without our *knowing the Arguments* of the Inequalities which we seek. The Method of Curves and the Method of Residues, when the Arguments of the principal Inequalities are known, often make it easy to find the others.

XLIX.

The Law of Continuity is this:—that a quantity cannot pass from one amount to another by any change of conditions, without passing through all intermediate magnitudes according to the intermediate conditions. It may often be employed to disprove distinctions which have no real foundation.

L.

The Method of Gradation consists in taking a number of stages of a property in question, intermediate between two extreme cases which appear to be different. It is employed to determine whether the extreme cases are really distinct or not.

LI.

The Method of Gradation, applied to decide the question, whether the existing geological phenomena arise from existing causes, leads to this result:—That the phenomena do appear to arise from existing causes, but that the action of existing causes may, in past times, have transgressed, to any extent, their recorded limits of intensity.

LII.

The Method of Natural Classification consists in classing cases, not according to any assumed definition, but according to the connexion of the facts themselves, so as to make them the means of asserting general truths.

LIII.

In the *Induction of Causes* the principal maxim is, that we must be careful to possess, and to apply, with perfect clearness, the Fundamental Idea on which the Induction depends.

LIV.

The Induction of Substance, of Force, of Polarity, go beyond mere laws of phenomena, and may be considered as the Induction of Causes.

LV.

The Cause of certain phenomena being inferred, we are led to inquire into the Cause of this Cause, which inquiry must be conducted in the same manner as the previous one; and thus we have the Induction of Ulterior Causes.

LVI.

In contemplating the series of Causes which are themselves the effects of other causes, we are necessarily led to assume a Supreme Cause in the Order of Causation, as we assume a First Cause in Order of Succession.

APHORISMS

CONCERNING THE LANGUAGE OF SCIENCE.

I.

In the Ancient Period of Science, Technical Terms were formed in three different ways:—by appropriating common words and fixing their meaning;—by constructing terms containing a description;—by constructing terms containing reference to a theory.

II.

In the Modern Period of Science, besides the three processes anciently employed in the formation of technical terms, there have been introduced Systematic Nomenclature, Systematic Terminology, and the Systematic Modification of Terms to express theoretical relations.

III.

In framing scientific terms, the appropriation of old words is preferable to the invention of new ones.

IV.

When common words are appropriated as technical terms, their meaning and relations in common use should be retained as far as can conveniently be done.

V.

When common words are appropriated as technical terms, their meaning must be modified, and must be rigorously fixed.

VI.

When common words are appropriated as technical terms, this must be done so that they are not ambiguous in their application.

VII.

It is better to form new words as technical terms, than to employ old ones in which the last three Aphorisms cannot be complied with.

VIII.

Terms must be constructed and appropriated so as to be fitted to enunciate simply and clearly true general propositions.

IX.

In the Classificatory Sciences, a systematic Nomenclature is necessary; and the System and the Nomenclature are each essential to the utility of the other.

X.

New terms and changes of terms, which are not needed in order to express truth, are to be avoided.

XI.

Terms which imply theoretical views are admissible, as far as the theory is proved.

XII.

If terms are systematically good, they are not to be rejected because they are etymologically inaccurate.

XIII.

The fundamental terms of a system of Nomenclature may be conveniently borrowed from casual or arbitrary circumstances.

XIV.

In forming a terminology, words may be invented when necessary, but they cannot be conveniently borrowed from casual or arbitrary circumstances.

XV.

The two main conditions of the Form of technical terms are, that they must be generally intelligible, and susceptible of such grammatical relations as their scientific use requires.

XVI.

In the composition and inflexion of technical terms, philological analogies are to be preserved if possible, but modified according to scientific convenience.

XVII.

When alterations in technical terms become necessary, it is desirable that the new term should contain in its form some memorial of the old one.

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